UCLouvain

lphys2266

2023

Physics of the upper atmosphere and space

5.00 credits	22.5 h + 7.5 h	Q2

Teacher(s)	Pierrard Viviane ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Main themes	Physics of gases and plasmas. The Sun andother stars. The interplanetary spaceand solar wind. The magnetosphere. Movement of particles in a magnetic field. Interactions Sun-magnetosphere. Ionosphere and plasmasphere. Neutral atmosphere. Planetary atmospheres.
Learning outcomes	**At the end of this learning unit, the student is able to :** **a. Contribution of the teaching unit to the learning outcomes of the programme (PHYS2M and PHYS2M1)** AA1: A1.1, A1.2, A1.5 AA2: A2.3, A2.4, A2.5 **b. Specific learning outcomes of the teaching unit** At the end of this teaching unit, the student will be able to : 1. describe space plasmas and the interactions between the solar wind and the magnetic field of the planets ; 2. know the atmospheric layers and the physical mechanisms that are implicated ; 3. use the appropriate kinetic et magnetohydrodynamic equations ; 4. evaluate the order of magnitude of the variables used to describe space plasmas ; 5. conduct a personal work on a chosen topic concerning space physics ; 6. develop a simple computer code to visualize the results ; 7. analyze data and results of models and discuss them ; 8. present results orally and in writing.
Evaluation methods	Written exam on the content explained during the course for 15/20, completed by exercises and a personal work with presentation for 5/20. A short individual written report on the personal work has to be sent by e-mail before the last course for a deadline date specified during the course, and an individual oral presentation of its content is made by the student during the last course(s). If the report is not sent in time, it can still be sent for the session of September. Part of the final note related to the personal work takes also into account continuous evaluation during the quadrimester, especially for exercises.
Teaching methods	Lectures. Integrative project. Personal work. Exercises.
Content	**The Sun, our star :** stars (formation, Hertzsprung-Russell diagram, fusion, abundance of the elements) – description of the inner Sun (radiative zone, convective zone) – the solar atmosphere (photosphere, chromosphere, corona) – sunspots, solar activity cycle – solar eruptions (CME, flares, prominences…) – coronal holes. **Physics of gases and plasmas :** definitions and properties – kinetic theory: microscopic approach – velocity distribution functions – fundamental equations : Liouville, Boltzmann, Vlasov, Fokker-Planck – Debye length – hydrodynamic theory : macroscopic approach – fundamental equations : continuity, momentum, energy – system closure: Euler approximation, Navier-Stokes – links and differences.

	Application to planetary and stellar atmospheres : hydrostatic equilibrium – neutral atmosphere – ionized atmosphere – hydrodynamic models – Parker's model of the solar wind – mean free path – exosphere – liberation velocity – satellites – escape flux (Jeans) – solar wind – hydrogen and helium escaping from Earth. **The interplanetary space :** discovery of the solar wind – solar magnetic field – observations: slow and fast solar winds – application of the fundamental equations for plasmas : hydrodynamic and kinetic models – heliosphere – comets. **The magnetosphere :** origin of the geomagnetic field – inversion of polarities – dipole – International Geomagnetic Reference Field – planetary magnetospheres – description of the different regions of plasmas – currents – magnetopause – polar cusps – plasma sheets –auroras – Van Allen belts. **Movement of particles trapped in a magnetic field :** decomposition in 3 superimposed movements – gyromotion – oscillation - azimuthal drift – drift forces (gravity, electric and magnetic forces, polarization) – adiabatic invariants – application to the Van Allen belts and to the plasmasphere. **Sun-magnetosphere interactions :** magnetic storms – substorms – space weather – indexes of geomagnetic activity (Kp, Dst, Ae, PC, ...) – reconnexion. **Ionosphere and plasmasphere :** sources of ionization – ionospheric layers – propagation of radio waves – perturbations due to solar activity – influence on satellites and GPS – plasmasphere – formation of the plasmapause – co-rotation electric field – convection electric field – polar wind. **Neutral atmosphere :** temperature profile – troposphere – stratosphere – mesosphere – thermosphere – photodissociation – chemical reactions – ozone. **Planetary atmospheres :** Mercury – Venus – Mars – Jupiter – Saturn – Uranus – exoplanets.
Inline resources	Powerpoint available on Moodle
Bibliography	Pierrard V., 2009, *L'environnement spatial de la Terre*, Presses Universitaires de Louvain, (ISBN 978-2-87463-195-5), 214 pages. (conseillé)
Other infos	All information concerning the content of the course and the evaluation will be specified during the first course.
Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Geography : Climatology	CLIM2M	5		
Master [60] in Physics	PHYS2M1	5		
Master [120] in Physics	PHYS2M	5		